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Physiology, Respiratory Quotient

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Introduction

Respiration is the process by which the respiratory substrate is broken down to release energy. The 2 main ope factors of cell respiration are aerobic and anaerobic respiration, where aerobic respiration requires the presenc of oxygen and anaerobic respiration does not. The most common respiratory substrate is glucose, which has a carbon compound. The substrate is metabolized through glycolysis, the TCA cycle, the electron transport chai oxidative phosphorylation. Cells can produce and store ATP through these cycles, and carbon dioxide is produ a by-product. It is important to understand the carbon dioxide levels produced from different substrates becau levels can destroy the body. Healthcare professionals can recommend that a patient alter his or her diet, partic for those with pulmonary and liver conditions, to increase the release of CO_2 and avoid respiratory fatigue an utilize it as a prognostic factor, respectively.[1] The respiratory quotient, or the respiratory ratio (RQ), is the v of carbon dioxide released over the volume of oxygen absorbed during respiration. It is a dimensionless numb in calculating the basal metabolic rate when estimated from carbon dioxide production to oxygen absorption. uptake is a form of indirect calorimetry and is measured by a respirometer directly at the tissue or mouth.

Respiratory Ratio

RQ = Vol CO_2 released/Vol O_2 absorbed

It is calculated for a particular substrate ie, carbohydrates, organic acid, fat, and protein. Carbohydrates are ox through aerobic respiration, producing an equal ratio of CO_2 release and oxygen consumption. Subsequently, for fat, protein, and anaerobe is 0.7, 0.8, and 0, respectively. If a mixture of the substrates is consumed, then th ratio collectively is 0.8.[2]

Function

When inspired oxygen is collected in the alveolar sac, perfusion occurs through the alveoli's capillary network perfused oxygen is transported by the red blood cell to the surrounding tissues. As blood travels through the c bed, oxygen is released from the RBC to the respective tissue site. Concurrently, the tissue releases CO_2 throu metabolic processes into the red blood cells, delivering it to the lungs.

Normal Respiration

- Vol CO_2 = 200 mL/min and Vol O_2 = 250 mL/min, resulting in 0.8 respiratory ratio

In the presence of macronutrients, oxygen is required to break down carbohydrates, fat, and protein. Carbohyc ($C_6H_{12}O_6 + 6O_2$) have a 6-carbon chain and metabolize via glycolysis to form 2 pyruvate substrates, releasin as a by-product when converting to acetyl CoA. CO2 is a by-product in the Krebs cycle when 2-carbon acetyl reacts with 4-carbon citrate, producing 3 CO2 in each metabolizing cascade. Suppose the starting molecule is acid containing 12, 18, 20, or 22 carbon molecules. In that case, it goes through the process of beta-oxidation acetyl Co-A, which does not generate carbon dioxide. Therefore, less CO2 is generated for every oxygen cons when using fat over carbohydrates as fuel.

Related Testing

Indirect Calorimetry

To validate RQ, it is important to calculate heat production by first measuring pulmonary gas exchange, know indirect calorimetry. The method for measuring inspired oxygen and expired carbon dioxide is to calculate the energy expenditure (REE) and respiratory quotient (RQ). REE allows nutritionists to understand how much th to feed their patients.

Respiratory Quotient and Respiratory Exchange Ratio [3]

Respiratory Exchange Ratio (RER) directly measures Vol CO_2 released/Vol O_2 absorbed at the mouth and doe require invasive procedures. On the other hand, the respiratory quotient measures directly at the tissue, requiri arterial and venous catheter while monitoring blood pressure for optimal results.

Carbohydrates are oxidized through aerobic respiration using RER, resulting in an equal ratio of CO_2 release a oxygen consumption; this implies that 100% of carbohydrates are consumed to produce ATP.

- $C_6H_{12}O_2 + 6\ O_2$ -> $6CO_2 + 6\ H_2O$ + Energy
- RQ= 6 CO_2 /6 O_2 = 1.0

When fat is oxidized and measured using RER, the outcome is reduced CO_2 production for every oxygen mol consumed.

- $C_{16}H_{32}O_2 + 23\ O_2$ -> $16CO_2 + 16\ H_2O$ + Energy
- RQ= 16 CO_2 / 23 O_2 = 0.7

When protein is the respiratory substrate, it reduces CO_2 production for every oxygen molecule consumed.[4]

- $C_{72}H_{112}N_{18}O_{22} + 77\ O_2$ -> $63O_2 + 38\ H_2O$ + Energy
- RQ= 63 CO_2 / 77 O_2= 0.9

Clinical Significance

Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is a pulmonary disease that causes chronic obstruction of airf Chronic inflammation of the bronchioles, along with mucous production, causes them to become deformed an

narrow, limiting the airflow as a person exhales. Because the patient cannot fully exhale, carbon dioxide rema the alveoli due to the loss of elasticity of the sac. The patients suffer from shortness of breath, productive coug respiratory acidosis, and complicated pneumonia. In 1992, a study showed that carbohydrate-rich food increas production of CO_2, leading to an increase in respiratory rate and eventually respiratory failure. On the contrar rich meals decrease the production of CO_2, leading to reduced alveolar ventilation and minor improvement in respiration in patients who initially have an RQ ratio greater than 0.75.[5]

Non-Insulin Dependent Weight Gain

The respiratory quotient can be used to predict weight gain in non-insulin-dependent diabetic patients. Norma diabetic patient has insulin-resistant receptors, which results in hyperglycemia. This prevents metabolization f occurring via glycolysis, therefore increasing lipolysis. As mentioned, an increase in lipolysis reduces the pro of CO_2. A study done in 1998 demonstrated an inverse correlation between RQ ratio and serum glucose level insulin-dependent diabetes mellitus treated with oral hypoglycemic agents or insulin. Patients on the oral hypoglycemic agents with a higher BMI verified that their RQ ratio was much higher than those of average B After following them for a year, a weight gain of 3 kg was noticed in 50% of the patients, and an increase in t ratio. This study concluded that the RQ ratio is a valid predictor for weight gain in diabetics treated with oral [6]

Nutrition Guide for Sick Patients

The indirect calorimetry and respiratory energy expenditure aids in calculating the ideal kcal patients need to per day, especially when unable to estimate caloric requirements, inadequate clinical response to a predicted e or clinical signs of over and under-feeding. Patients who are morbidly obese or suffering from sepsis have an alteration in their VCO_2 release and VO_2 consumption. For this reason, a daily RQ and indirect calorimetry a essential to optimize their diet and reduce hospital stays.[7][8]

- REE = (kcal/d)= (VO_2 x 3.94) + (VCO_2 x 1.11) x 1440

Review Questions

- Access free multiple choice questions on this topic.
- Comment on this article.

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